SURFACE WATER STATION DESCRIPTION
TRAVERTINE SPRINGS IN FURNACE CREEK WASH - 362629116495601
DEATH VALLEY NATIONAL PARK, CA.

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All figures referenced in this report are located in the Appendix.

LOCATION

The gaging station (station) at Travertine Springs in Death Valley National Park (DEVA) is located at N 36° 26' 29" and W 116° 49' 56" in Inyo County, CA, in the SW ¼ NE ¼ NE ¼ of Section 26, T. 27 N., R. 1 E. within Hydrologic Unit 18090203.

ACCESS

The park is about 2.5 hours from Las Vegas, Nevada. From Las Vegas, NV take State Route SR-160 north to Pahrump, NV for 57 miles (traveling northwest). Turn left (west) on Bell Vista Road and travel 26 miles. (Bell Vista Road becomes State Line Road.) Turn right (north) on SR-127 for 0.2 miles. Turn left (west) on SR-190 and travel 30 miles (**Figure 1**).

To access the station take Highway 190 south from the Furnace Creek Ranch in DEVA. The station is located approximately 1.5 miles southeast of the intersection of Highway 190 and Badwater Road, and approximately 1.3 miles south of the Furnace Creek Inn on Highway 190 (**Figure 2**).

Two-wheel drive, low clearance vehicles are suitable to reach this station.

NOTIFICATION

Prior to visiting the station check in with the park hydrologist for DEVA.

ESTABLISHMENT

The NPS established the Travertine Springs station in 1978 to monitor the discharge of Travertine Springs, identify trends in spring flow and detect the effects of ground-water pumping on flow over time.

In 1989, a monitoring program was agreed to between the Barrick Bullfrog gold mine and the NPS as a condition attached to several water right permits. The monitoring plan included measurement of ground-water production and quarterly water levels in several monitoring wells by the mine, and monitoring the discharge of selected springs (Texas, Travertine and Nevares) by the NPS. In June, 2001 Barrick Bullfrog, Inc. closed their mining operation and transferred ownership of the monitoirng wells to the United States Geological Survey (USGS). Water level monitoring continues informally by the USGS.

ELEVATION

The elevation of Travertine Springs is estimated to be 380 feet above sea level (USGS 7.5 minute topographic Quadrangle, Furnace Creek, CA. Provisional edition 1988.)

DRAINAGE AREA

The Death Valley ground-water flow system encompasses an area of about 15,800 mi^2 (Harrill and others 1988).

HYDROLOGIC CONDITIONS

Death Valley is located at the terminus of a vast regional ground-water flow system in the Basin and Range physiographic province. The primary aquifer types within the regional flow system are Paleozoic carbonate rock, Tertiary volcanic rock and Cenozoic valley-fill aquifers. The carbonate rock aquifer is the principal regional aquifer within the Death Valley ground-water flow system. Ground water moves generally from recharge areas at higher elevations in the north to lower elevation valleys in the south, and ultimately to Death Valley. Because of the immense size and complexity of the flow system, it is often divided into subregions, and the subregions are further divided into ground water basins and sections.

The Alkali-Flat Furnace Creek basin is one of three ground-water basins within the Central Death Valley subregion. Discharge from this basin occurs at the springs in the Furnace Creek area including Texas, Travertine and Nevares Springs. These three springs appear to be related to a major fault zone known as the Furnace Creek fault zone. Low permeability material along the Furnace Creek fault zone may form barriers to flow causing ground water to flow upwards through Tertiary lacustrine deposits and alluvium where it is discharged at springs.

The current water collection system in the Furnace Creek area consists of collection boxes at Travertine Springs, a collection gallery in the Furnace Creek Wash, an artificial tunnel at Texas Springs, and an artificial tunnel at the Furnace Creek Inn (**Figure 3**). Water is collected from several outlets of Travertine Springs in order to supply potable water to the NPS, the Xanterra Parks and Resorts, and the Timbisha Shoshone Indian tribe in the Furnace Creek area (Martin 1999). Water is generally of good quality. Water from Travertine Springs flows by gravity to a 2-million gallon tank located northeast of the Furnace Creek Inn.

Travertine Springs is located in a riparian habitat approximately 1-mile south of the 2-million gallon water tank and just east of Highway 190 (**Figure 4**). Four distinct lines make up the Travertine Springs water system, all of which provide some potable water supply. Collection boxes for both line #1 and line #2 have overflow pipes. Overflow from line #1 is routed to surrounding riparian vegetation. Lines #3 and #4 do not have collection boxes, but have individual overflow pipes located along the distribution line. Water from the four lines is routed to a common collection point, the Travertine Springs measurement box. The measurement box contains a 9-inch Parshall flume where discharge is measured. The flume at Travertine Springs is a cutthroat flume, which is similar to a Parshall flume except that it lacks a downstream diverging section or spillway crest (Plasti-Fab 2003). From the Travertine Springs measurement box, water is transported by a 12-inch pipe to the Furnace Creek Wash measurement box. At the Furnace Creek Wash measurement box, Travertine Springs water is combined with water from Furnace Creek Wash and routed to the 2-million gallon storage tank through a 12-inch pipe.

Statistically significant downward trends were recorded for discharge at Travertine Springs from 1992 through 2000 (Fenelon and Moreo 2002). The decline in discharge may be the result of long-term equilibration following the Landers/Little Skull Mountain earthquakes, which occurred on June 28 and 29, 1992, respectively, or it may be linked to both earthquakes and ground-water pumping in the Amargosa Farms area (Fenelon and Moreo 2002). A list of significant earthquakes of the world reported by the USGS accompanies each water year folder for that period of record as a reference.

The climate of DEVA is arid and may be characterized as a rain-shadow desert climate. The summers are extremely hot and dry and the winters are mild. Average summer temperatures are about 100 °F and average winter temperatures are about 60 °F. Winter storms in the Death Valley region are usually low intensity and account for approximately 65 to 75 percent of the annual precipitation (Fenelon and Moreo 2002). In the summer, convective rainstorms are typical, as exemplified by the flood of August 2004. Death Valley National Park receives an average of only 2 inches of precipitation per year. The potential evapotranspiration rate in the area is about 150 inches.

Vegetation cover is generally sparse but is concentrated in areas where springs and seeps are located, such as the area surrounding Travertine Springs. Water discharging from Travertine Springs supports a riparian area noted for at least eight endemic special-status species and a biologically and culturally significant mesquite bosque. Wetland and riparian areas associated with the springs are the most biologically diverse and rarest habitats in Death Valley.

Large amounts of ground water have been pumped from the regional flow system. Ground-water pumping to support irrigation and agriculture began as early as 1913. Between 1913 and 1998, about 90 percent of the ground water pumped was for irrigation (Moreo and others, 2003). Most of the pumping has occurred in the Amargosa Desert, which is upgradient of Travertine Springs, and in Pahrump Valley. Mining, public supply and commercial use accounted for about 8 percent of the pumpage, and domestic use accounted for about 2 percent (Moreo and others 2003).

Major ground-water development is currently proposed to support growing urban areas like Las Vegas, NV and Pahrump, NV. Because surface water is seasonal and not a dependable water source for development, ground-water resources are being used to support growing urban demands. Excessive ground-water pumping has the potential to deplete aquifer storage and reduce spring discharge over time.

CHANNEL AND CONTROL

Control for the Travertine Springs station is the crest or throat of the 9-inch cutthroat (Parshall) flume. The crest or throat of the flume is the point of zero flow (PZF), which is 7.0 foot on the staff plate (**Figure 5**). The PZF serves as a control for the station and as the gage datum for surveys. The dimensions of the cutthroat flume are 9 inches by 3 feet. The rating for a free-flowing Parshall flume is valid for a cutthroat flume if water *falls* from the end of flume, such as it does at Travertine Springs station (Skogerboe 1977). The channel is a straight concrete trough that carries the flow of the springs. After discharge is measured in the 9-inch cutthroat (Parshall) flume, most spring water is routed away from the station to the 2-million gallon water storage tank and some spring water is released to surrounding riparian vegetation. Four springs/lines have been set up with water collection structures at the Travertine Springs station. **Table 1** lists a description of each of the four spring lines at Travertine Springs.

Travertine Springs Lines	Description
1	Spring at southeast end of springs. Spring furthest away with special adaptation for snail protection.
2	Spring just east of dirt road which leads to Texas Springs.
3	Spring about 100 yards north of measurement site.
4	Spring immediately north of measurement site.

Table 1: Description of 4 Spring Lines at Travertine Springs Gaging Station. (Roche 2001)

The developed springs (**Table 1**) are the most southeasterly of the springs, which are furthest up the wash. Two of the developed pipes are along the upper spring line and two are along the lower spring line, which is closer to Highway 190 (**Figures 4**). Travertine Springs lines numbers 1 and 2 have collection boxes (**Figures 6 & 7**, respectively). Water is collected from selected spring areas by four french drains and collection boxes, such as the collection box at line #1 (**Figure 8**). Spring water is then carried via pipelines to the Travertine Springs station. Perforated PVC piping ranging from 100-200 feet in length carries the spring flow and has been buried and backfilled with gravel in the spring or seep areas. A concrete headwall forces the water to pool and enter the perforated pipe rather than flowing past the pipe (Martin 1999). The water is diverted through a main collection box then piped into the Furnace Creek wash collection gallery and subsequently into a collection tank used for potable water. Overflow from the collection galleries is discharged to riparian vegetation surrounding the springs, such as the overflow from line #1 (**Figure 9**).

On February 22, 2001 all 4 lines were shut down due to fecal coliform contamination in the Travertine Springs water distribution system. Lines numbers 3 and 4 were brought back online on February 23, 2001 because they were found to be clear of fecal coliform contamination. On March 30, 2001 line number 3 was brought back online because it was found to be clear of fecal coliform contamination. Currently (February 2, 2006) line number 1 remains offline due to ongoing fecal coliform contamination.

Discharge may be affected by evapotranspiration or alteration to the collection galleries. On November 21, 2002 vegetation was removed from lines 3 & 4. Line tests were performed on all 4 lines at Travertine Springs station on March 11, 2003 in order to verify flows due to vegetation removal. Other line tests performed at the Travertine Springs station are listed in the History section of this Station Description and also in Section 5 "Other Station Data and Analyses," of the Travertine Springs station History Folder.

GAGE

Flow from the four spring lines is diverted through a collection box and a straight concrete trough that serves as the channel (3 feet by 26 feet by 5 feet, including concrete walls) and then a 9-inch Parshall flume, which serves as the control (**Figures 10 & 11**). The dimensions of the flume are 3 feet by 9 inches. The dimensions of the throat of the flume, also known as the crest, are 9 inches by 1 foot. Spring flow is fairly turbulent upon entering the concrete trough from the four collection lines and becomes more laminar further downstream. The throat of the flume is set to the level of point of zero flow (PZF). A Stevens GS 98 data logger (primary recorder), serial number 163186B) with a shaft encoder and a Stevens F chart recorder (back up recorder) and float are installed to measure flow through the flume. The instrumentation sits over a stilling well inside a fiberglass box to measure gage height of the flume (**Figure 12**). The vertical staff gage (6.76 – 10.12 feet) attached to the side of the stilling well serves as a reference gage (**Figure 13**). The data logger records unit values (gage height measurements) in 15-minute intervals and the chart recorder provides a continuous record of gage height measurements where increments on the chart represent 12 hours.

Discharge is calculated using a standard rating equation for a 9-inch Parshall flume. The rating equation for the Travertine Springs flume is:

$$Q = 3.070 * G^{1.53}$$

where Q equals discharge in cubic feet per second, and G equals gage height in feet.

Gage height is the only parameter that is recorded and it is logged every 15-minutes. Data are reported in calendar year format by the NPS-WRB.

HISTORY

The station has remained at its original location since its establishment by the NPS.

1977	Plans for springs collection and flume design completed by NPS - Denver Service Center.
June 5, 1978	Travertine Springs station collection lines and flume construction as described in Furnace Creek Site Plan completed by Stratton Brothers Construction Company. (**Figures 12** & **13**).
December 11, 1980	USGS installs and completes the first level survey of the station.
August 31, 1989	Pipe flow line test performed on four lines at Travertine Springs station. (See Section 5, *Other Station Data and Analyses,* of History folder for a summary of all line tests).

August 31, 1989	LOTUS 1-2-3 software program used for Travertine Springs station data processing.
September 1989	Stevens F chart record and digital mean daily data for Travertine Springs station begins. Records are stored in NPS-WRB docket files.
March 19, 1990	Stevens shaft encoder and type A/F data logger added to Travertine Springs station.
June 28, 1992	Landers earthquake occurred in California (Fenelon and Moreo 2002)
June 29, 1992	Little Skull Mountain earthquake occurred ~30-km southeast of Yucca mountain (Lohman et al. 2002)
April 18, 1994	Pipe flow line test performed on four lines at Travertine Springs station. (See Section 5, *Other Station Data and Analyses,* of History folder for a summary).
January 7, 1998	Microsoft Excel 5.0 software used for Travertine Springs station data processing. LOTUS 1-2-3 software no longer used for data processing.
October 21, 1998	Fiberglass box installed over stilling well to house equipment at Travertine Springs station.
April 1999	Microsoft Excel 7.0 software used for Travertine Springs station data processing. Microsoft Excel 5.0 no longer used for data processing.
December 9, 1999	Stevens GS 98 data logger replaced the A/F data logger for the Travertine Springs station.
May 24, 2000	Steel lids replaced aluminum lids over approach to flume.
June 8, 2000	Pipe flow line test performed on four lines at Travertine Springs station. (See Section 5, *Other Station Data and Analyses,* of History folder for a summary).
Febraury 22, 2001	DEVA staff stopped flow from lines 1, 2, 3, & 4 due to fecal coliform contamination (Roche 2001).
Febraury 23, 2001	DEVA staff stopped flow from lines 1 & 2 (collection galleries furthest from the monitoring site) due to ongoing fecal coliform contamination. Lines 3 & 4 brought back online by DEVA staff because clear of fecal coliform contamination (Roche 2001).
March 8, 2001	Maintenance crews removed several date palms from the exclosure surrounding the intake for line 2 to reduce the possibilty of further fecal coliform contamination (Roche 2001).
March 30, 2001	Line 2 at Travertine Springs station was brought back online because line 2 clear of fecal coliform contamination. Line 1 remains offline (Roche 2001).
April 25, 2001	Pipe flow line test performed on three lines (line numbers 2-4) at Travertine Springs station. No test performed on line 1 because it was offline due to fecal coliform contamination. (See Section 5, *Other Station Data and Analyses,* of History folder for a summary).

January 1, 2002	ADAPS software used for Travertine Springs station data processing. Microsoft Excel 7.0 Software no longer used for data processing.
February 13, 2002	Pipe flow line test performed on all four lines at Travertine Springs station, but it is uncertain if all flow was back in line 1 (See Section 5, *Other Station Data and Analyses,* of History folder for a summary).
November 21, 2002	Vegetation removed from lines 3 & 4 (See Correspondence from Terry Fisk to other NPS staff on November 21, 2002 in Section 6, *Correspondence and Miscellaneous Supporting Material*, of History Folder)
March 11, 2003	Pipe flow line test performed on four lines at Travertine Springs station. (See Section 5, *Other Station Data and Analyses,* of History folder for a summary).
May 28, 2003	A new reference point, "top of nail in bolt" (**Figure 14**), from which tape-downs will be measured, was established. Top of nail in bolt = 10.42 ft gage height.
October 21, 2004	Pipe flow line test performed on four lines at Travertine Springs station. (See Section 5, *Other Station Data and Analyses,* of History folder for a summary).

REFERENCE AND BENCHMARKS

Reference marks (RM's) have been established at the Travertine Springs station for elevation control. RM's can be defined as control points located near the station that are surveyed to calibrate horizontal and vertical locations of all surveyed points. **Table 2** lists historical station level surveys that have been carried out at the Travertine Springs station. A sketch that shows the location of the station level reference marks surveyed for the station can be found in Section 4 "Summary of Gage Levels" of the Travertine Springs History Folder.

DATE	CREW	Nail @ 10 ft on staff plate	RM: Bolt on concrete canal	Throat/crest/PZF bottom
12/11/1980	USGS	9.01*	1.87	-
4/18/1994	NPS	10.00	1.86	7.00
6/5/1996	NPS	10.00	1.86	7.00
4/11/1997	NPS	10.00	1.87	7.01
5/1/1998	NPS	10.00	1.86	7.01
12/7/2000	NPS	10.00	1.85	7.00
10/25/2001	NPS	10.00	1.86	7.00
11/6/2002	NPS	9.99	1.86	7.00
5/28/2003	NPS	10.00	-	-

- Data not collected. * USGS crew may have surveyed a different point.

Table 2: Reference and Benchmark surveyed elevations for Travertine Springs station.

DISCHARGE MEASUREMENTS

Flow from Travertine Springs is channeled through a concrete trough and measured in a 9-inch free-flowing cutthroat (Parshall) flume. The channel dimensions are 25 ft by 3 ft by 5 ft (**Figure 5**). The location for collecting manual discharge measurements at the station is 3-feet upstream from the throat (or crest) of the flume, which is marked with an elliptical hole etched into the lip of the concrete wall of the channel (**Figure 5**). The staff gage and stilling well are located along the converging walls of the concrete channel (trough) just before the flow reaches the throat of the flume (**Figure 13**).

HIGH FLOWS

The highest mean daily discharge recorded for the Travertine Springs station was 1.94 cfs measured from November 30, 1993 through December 2, 1993 and December 6, 1993 through December 11, 1993. The range of mean daily discharge values is 0.70 to 1.94 cfs, with a mean of 1.68 cfs. From February 22, 2001 to present (February 2, 2006), flows for line number 1 have been estimated using the pipeline flow test results from June 8, 2000. It is necessary to estimate line number 1 flows because it was taken offline on February 22, 2001 and remains offline, due to fecal coliform contamination. **Figure 15** illustrates a plot of the mean daily discharge at Travertine Springs station over time. The mean daily discharge plotted in red from 2001 to present represents the discharge of all the lines at Travertine Springs, including discharge estimated for line number 1.

The flow from Travertine Springs is relatively stable and does not fluctuate with storm events.

POINT OF ZERO FLOW

The point of zero flow (PZF) for the Travertine Springs station is 7.0 feet and is located at the crest (throat) of the flume (**Figures 5 & 10**) The PZF is surveyed regularly as part of the station level surveys.

WINTER FLOW

The flow of Travertine Springs is relatively consistent and does not vary in the winter.

REGULATION AND DIVERSION

The NPS diverts some of the Travertine Springs flow for potable water use within the park. Other diversions of Travertine Springs flow include diversions to Xanterra Parks and Resorts and the Timbisha Shoshone Indian tribe.

ACCURACY

The discharge record for the Travertine Springs 9-inch cutthroat (Parshall) flume is considered excellent. The Plasti-Fab flume is installed in concrete and level surveys (Summary of Levels, Section 4 of the History Folder) indicate the flume is stable and installed as recommended in the Water Measurement Manual, Bureau of Reclamation, U.S. Department of the Interior (2001).

The NPS and USGS performed manual discharge measurements with a pygmy current meter from 1979 to 2004 to check the calibration of the flume. However, we were unable to measure the 25 to 30 intervals normally required by the USGS (Rantz et al. 1982). Therefore, many of the manual discharge measurements were rated "fair." This is due to the narrow width of the approach into the flume. Differences between the discharge computed from the flume and USGS manual discharge measurements for 1979 through 1982 ranged from -6.5 to 0.0 percent (Section 2, shift analysis of the History Folder). Differences between flume discharge and NPS manual discharge measurements before November 1994 ranged from -0.5 to 0 percent. A special flow test of 5 discharge measurements (#5-9) was conducted on November 29, 1994, to verify the rating of the 9-inch flume at various gage heights (0.34 to 0.72 feet) and measure the discharge for each of the Travertine Springs lines. Differences between discharge computed from the flume and manual discharge measurements ranged from -3.9 to 14.1 percent.

The NPS and USGS refined techniques after a site visit to Texas Springs in November 1994 to improve the accuracy of the manual discharge measurements by improving depth measurements and applying a velocity coefficient (.75) for the intervals next to the smooth vertical walls (Section 6, Correspondence with USGS, Texas Springs History Folder). All pre-November 1994 NPS measurements were recalculated to include the mean vertical velocity coefficient. From 1996 through 2004, differences between discharge computed from the flume and NPS manual discharge measurements ranged from -7.1 to 6.7 percent.

COOPERATION

Travertine Springs station is maintained by the NPS-WRB. DEVA staff visit the station monthly to inspect data loggers, the chart recorder and collect data records. NPS-WRB processes and analyzes the data using ADAPS, collects periodic discharge and survey data, and provides QA/QC for all data collection and analyses.

The USGS has been a cooperator in the monitoring of the Travertine Springs station. USGS staff collected the first discharge measurements at the station (1979, 1980, and 1982) and conducted one survey for Travertine Springs station on December 11, 1980.

LOCAL PARK PARTNER

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